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Research Article

The role of the Arabian anticyclone core position in the spatial displacement of precipitation cores and moisture transport pathways of precipitating systems (Affecting southern Iran)

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Abstract

The general structure of synoptic patterns in any region develops out of the interaction among several systems, among which one or two systems have more prominent roles compared to the others. In Western Asia, the Arabian subtropical Anticyclone (ASTAC) system has a determining role in the structure of the atmospheric patterns of the region. This research was conducted with the aim of investigating the role of this system in the spatial displacement of high-pressure cores and the track of precipitation systems in Iran. This study analyzed 40 strong precipitation systems in the southern part of Iran. First, the atmospheric data of these systems were extracted from the NCEP/NAR site for 48 h up to the end of the precipitation period across all troposphere levels. The high-pressure central core was extracted across all levels, and eventually, the cores of 700 hPa were chosen to locate the site of deployment of the cores. Then, the combined maps of the special stream and moisture, as well as the altitude maps for routing the system, humidity advection, and spatial displacement of Mediterranean trough at the levels of 850 and 700 HPa were chosen. The precipitation distribution map of each system was prepared, and the high-precipitation core was determined. Finally, the distance between the precipitation and high-pressure cores was measured. The findings indicated that the high-pressure cores of ASTAC were established in four general regions. The placement location of the cores determined the track of precipitation systems towards Iran and the precipitation zone of each system. In all cases, the humidity of systems was first advected through ASTAC cellular anticyclonic circulation over Sudan and Ethiopia (Sudan low). They were then advected through the southern streams of the Mediterranean trough over Arabia and Iran. The protraction and depth of troughs also had a close relationship with the location of ASTAC core establishment in a way that the high-pressure cores had a westward displacement. The same occurred for the axes of troughs and vice versa.

Keywords: Arabian subtropical anticyclone, Iran, Low pressure Sudan, Moisture advection, Routing precipitation systems.

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Introduction

The general circulation of the atmosphere generates large-scale planetary systems, among which subtropical high-pressure systems are considered some of the most stable, extensive, and influential features of the tropospheric circulation. These systems have relatively stable cores in both hemispheres, and based on their geographical locations, they are assigned different names. The Azores High, African High, and Arabian Subtropical Anticyclone (ASTAC) are among the most important subtropical high-pressure systems in the Northern Hemisphere (Lashkari et al, 2017). The general circulation of the atmosphere plays a determining role in the formation and development of climatic characteristics at both regional and local scales. It also influences atmospheric circulation patterns in adjacent as well as remote climate regions (Yin, 1994; Yang et al, 1992; Enomoto et al, 2003; Enomoto, 2004). Subtropical high-pressure systems are among the most persistent components of atmospheric circulation and play a significant role in regulating regional climate variability. Over Southwest Asia, the Arabian Subtropical Anticyclone represents one of the dominant circulation systems, influencing atmospheric stability, moisture transport pathways, and precipitation variability. Early investigations of subtropical high-pressure systems over Iran and the surrounding regions focused primarily on their seasonal variations and synoptic characteristics (Hejazizadeh, 1993). Subsequent studies revealed that the geographical position of subtropical high-pressure centers varies considerably across different levels of the troposphere, highlighting the importance of their vertical structure in regional climate analyses (Ghaemi et al, 2009). The spatial variability of the subtropical high over southern Iran and its relationship with seasonal precipitation have also been investigated, particularly in relation to summer precipitation events (Saligheh and Sadeghinia, 2010). The displacement and intensity of the Arabian Subtropical Anticyclone have been recognized as important factors influencing precipitation variability over Iran. Khoshakhlagh et al. (2011) demonstrated that the annual migration of the subtropical high-pressure belt, particularly the southern branch of the ASTAC, plays a significant role in modulating winter precipitation variability in southwestern Iran. Similarly, Lashkari and Mohammadi (2015) showed that the westward displacement of the ASTAC is associated with widespread and severe drought conditions across Iran. Further studies have confirmed the importance of ASTAC spatial variability in controlling regional precipitation patterns and atmospheric circulation anomalies (Karimi et al, 2019; Lashkari et al, 2017). Moisture transport associated with atmospheric circulation systems is another fundamental factor governing precipitation variability in Southwest Asia. Previous studies have highlighted the role of subtropical jets, Red Sea troughs, and high-pressure systems in transporting moisture from southern water bodies toward the Middle East. The subtropical jet facilitates the transport of warm and humid air masses from eastern Africa and the Gulf of Aden region toward the Middle East, particularly Egypt and Jordan (Dayan and Abramski, 1983). In combination with the Red Sea trough, this circulation pattern contributes to the transport of water vapor from the Arabian Sea toward the Middle East and the eastern Mediterranean region (Karichak and Albert, 1998). Furthermore, high-pressure systems and their spatial configurations have been recognized as important components of atmospheric circulation that regulate moisture transport pathways. The identification of moisture sources for precipitation systems has demonstrated that the surrounding oceanic regions of Southwest Asia provide the primary moisture supply for regional precipitation. Several studies have indicated that the Arabian Sea, Oman Sea, Persian Gulf, and Mediterranean Sea are among the most important moisture sources for precipitation over Iran (Izad Negahdar, 1991; Lashkari, 1996, 2019; Mofidi and Zarin, 2005). Farajzadeh et al. (2010) further identified the eastern Arabian Peninsula high-pressure region (western Arabian Sea) and the North African High as important moisture sources and injection regions for precipitation systems affecting Iran. Similarly, Amini et al. (2012) demonstrated that the presence of the Arabian Anticyclone facilitates moisture transport and contributes to the development of heavy precipitation events. Khosravi et al. (2017) found that moisture transport from the Arabian Sea at lower atmospheric levels and from the

Mediterranean Sea at higher levels plays a dominant role in the moisture fluxes associated with precipitation systems over Iran. Recent studies have focused on the dynamic role of the Arabian Anticyclone (AAC) and its vertical structure in precipitation processes. Jafari et al. (2023) investigated the influence of Arabian Subtropical High Pressure (ASHP) intensity on the zonal position of the Intertropical Convergence Zone (ITCZ) and demonstrated that variations in atmospheric fluxes and circulation patterns can strengthen or weaken the ASHP system. Karimi et al. (2022) showed that the AAC exhibits a distinct vertical structure during rainy periods and can be identified not only at lower atmospheric levels but also in the mid-troposphere at 700 and 500 hPa. They further indicated that spatial variations in the AAC center are associated with changes in precipitation patterns and intensity over Iran. Although the 500 hPa level is widely used in synoptic studies to investigate large-scale troughs, ridges, and wave patterns, the 700 hPa level is particularly suitable for examining moisture transport, moisture convergence, and precipitation organization processes. Darand and Pazhoh (2019), in their investigation of the role of the Arabian Anticyclone in precipitation over Southwest Asia, demonstrated that the maximum moisture flux convergence and the strongest spatial agreement between precipitation cores and moisture convergence occur within the 700 hPa layer over Iran. Similarly, Lavers and Villarini (2013) showed that mid-tropospheric moisture transport, particularly near the 700 hPa level, plays a crucial role in the development of extreme precipitation events.The relationship between the spatial position of the Arabian Anticyclone and precipitation patterns has also been examined through different atmospheric circulation classifications. Lashkari et al. (2019) reported that the onset of precipitation, particularly over southern and southwestern Iran, is closely associated with the position and movement of the Saudi Arabian subtropical high during autumn. Karimi et al. (2019) classified the mid-tropospheric circulation patterns of the Arabian subtropical high and found that, during cold periods, the location of the anticyclone over the Arabian Sea and the Gulf of Aden creates favorable conditions for precipitation occurrence over Iran, whereas during warm periods, it acts as a barrier to the penetration of precipitation systems. Furthermore, Mohammadi and Lashkari (2018) demonstrated that during extremely wet years in southern and southwestern Iran, the Arabian high-pressure system undergoes an eastward displacement, facilitating moisture transport from the Arabian and Oman Seas through the anticyclonic circulation toward precipitation-producing systems. Despite extensive investigations of the Arabian Anticyclone, moisture sources, and precipitation variability over Iran (Lashkari et al, 2017; Lashkari and Mohammadi, 2019), the relationship between the geographical displacement of the AAC core, moisture transport pathways, and the spatial migration of precipitation centers remains insufficiently understood. Therefore, the present study aims to investigate the role of AAC positioning at the 700 hPa level in modifying moisture transport pathways and controlling the spatial distribution of precipitation cores over southern Iran.

Materials and Methods

In this study, in order to detect the role of the ASTAC core establishment location in the advection of humidity into the Sudan low system, the track of systems, the pattern of development in the Mediterranean trough, and the spatial displacement of the high-precipitation core, the following research procedure was adopted. First, the statistics of the daily precipitation of 30 synoptic stations of the southern half of Iran were taken from the Iranian Meteorological Organization for a Seven-year statistical period. From among various precipitation systems, 40 pervasive and high-rainfall systems were chosen. Besides, the rainfall zone map of these systems was plotted in Arc-GIS 10.4. Then, the atmospheric data of the mentioned years were extracted for all rainy days using http://www.esrl.noaa.gov. Furthermore, using Grads software, the diurnal maps of these years were plotted at levels of 1000 to 500 hPa within the range of western 0° to eastern 80° as well as zero latitude (Equator) up to northern 50°. The ASTAC central core was determined as follows. The point that had the maximum geopotential height in comparison with the adjacent points within the longitude ranges of eastern 30° - eastern 80° and latitudes of northern 10° and northern 35° was considered as the high-pressure central core. The geographical position of the core center was calculated on the map with a precise latitude and longitude. The maximum geopotential height is considered as the most common criterion for determining subtropical high centers (Bell and Bosart, 1989); (Zhang et al, 2002); (Parker et al, 1989), and (Ghaemi et al, 2009). These cores were grouped as four general patterns based on the establishment location. In the next step, the spatial location of the high-precipitation core was determined and then the distance between the high-pressure core and the high-precipitation core was calculated. To determine the humidity advection, the axis of the special moisture chart of 850, 1000, and 700 hPa levels was plotted and the location of the axis of the highest special moisture was drawn. However, due to a relative consistency of the pattern of charts, eventually, the special moisture axis of 850 hPa level has been analyzed here. To determine the role of high-pressure core in the trough spatial displacement and trough axis, using Ncep/Ncar atmospheric data, the geopotential height chart of 850, 700, and 500 hPa levels was drawn. Eventually, the maps of 700 hPa were chosen for plotting the trough axis. Table 1 summarizes the specifications of the studied samples.

Table 1: The spatial location of the high-pressure central core, high-precipitation core, and spatial distance between the high-pressure core and high-precipitation core in the four patterns of the precipitation systems

Grouping of systems	**date**	**The high-pressure core location**		**Maximum precipitation site**	**Maximum precipitation (mm)**	**The maximum precipitation site location**		**The distance between the high-pressure core and the maximum precipitation site (km)**
		latitude	longitude			latitude	longitude	
Arabian Peninsula southern	23/4/2018	15	43	Izeh	43	31.85	49.86	1992
	24/12/2022	15	50	malekshahni	56.5	33.41	46.6	2067
	12/11/2021	25	48	Bandar_Deylam	66	30.05	50.17	600
	21/11/2020	19	55	Koohrang	101	32.45	50.12	1567
	17/12/2019	18	50	Jam	127	27.81	52.35	1112
	12/4/2018	13.37	50	Izeh	17	31.85	49.86	2046
	13/2/2018	18	44	Koohrang	46.5	32.23	50.11	1691
	14/3/2016	18.34	42.11	Safi abad	36.2	36.26	48.41	1666
	23/11/2017	17.33	48.95	Bandar lengeh	34	26.32	54.83	1185
	24/12/2016	20	51.47	Ilaam	51.8	33.63	46.43	1590
eastern Arabian Peninsula	29/4/2018	17.58	52.66	Shadegan	98	30.2	48.3	1466
	29/11/2020	20	58	Khark Island	133	29.26	50.31	1268
	1/12/2016	20	58	BASTACn	12.2	31.71	48	1637
	24/2/2018	16	52	Safi abad	40.6	36.26	48.4	1837
	12/2/2017	17.6	56.2	Fasa	73.9	28.96	53.68	1283
	13/2/2017	20	61	Jazire lavan	58.6	26.80	53.38	1082
	27/3/2016	22.8	59.24	Koohrang	39.8	33.26	50.11	1395
	28/3/2016	21.65	60.83	Kohrang	55.1	32.26	50.11	1597
	29/3/2016	19	60	Eghlid fars	21	30.90	52.63	1491
	7/4/2018	20	58	Shooshtar	35	32.5	48.8	1663
Hormuz Strait	3/12/2016	23.92	51.64	Koohrang	105	32.4	50.1	954
	03/11/2022	23	55	Shalamzar	45.8	32.04	50.82	1083
	2/12/2016	22	52	Koohrang	112	34.4	50.1	1170
	21/11/2017	24.31	57.23	Bushehr	84.1	28.96	50.81	820
	22/11/2017	23.38	59.17	Bandar dair	53.7	27.83	51.93	887
	25/12/2016	24.96	55.72	Koohrang	110	32.26	50.11	992
	26/12/2016	24.8	57	Koohrang	28.7	32.26	50.11	1065
	27/12/2016	24.46	56.58	Koohrang	77.9	32.26	50.11	1086
India and Pakistan cores	6/4/2018	19	78	BASTACn	34	31.71	48	1637
	19/12/2021	22	67	Koohrang	62	32.45	50.12	2029
	07/12/2019	28	68	Abdanan	109	32.99	47.42	2189
	08/12/2019	17	65	Borazjan	95	29.27	51.22	1995
	14/2/2017	25.1	66.37	Haji abad	75.1	28.6	55.9	1109
	15/3/2017	23.95	69.4	Safi abad	36.1	32.2	48.4	2253
	17/2/2017	24	75	Hasan abad	65.9	28.78	54.28	2131
	15/12/2017	14.7	69	Kish	24.6	26.5	53.98	2035
	16/12/2017	17.5	78	Kish	48.3	26.50	53.98	2704
	17/12/2017	23.6	72.4	Gheshm	30.9	25.91	55.91	1699

Results and Discussion

Grouping the high-pressure cores

As stated in the methodology section, along with various studies conducted on the atmospheric systems in the south of Iran and west of Asia by the author and his research team, we found that the ASTAC core displacement and the stretching pattern of its axis play a significant role in the synoptic patterns of the region. In this region, the role of ASTAC central core displacement on the spatial displacement of precipitation cores, humidity transfer axis, axis of troughs, and their synoptic patterns were emphasized. To this end, based on the position of the establishment of ASTAC cores, four general patterns were identified.

1. The pattern of Hormuz Strait cores
2. The pattern of India and Pakistan cores
3. The pattern of Arabian Peninsula eastern coast cores
4. The pattern of the Arabian Peninsula's southern cores

The summary of the synoptic patterns, humidity track, and source, trough axis, and the distance between the precipitation core and each of the precipitation systems in the four patterns is as follows:

The pattern of the Strait of Hormuz cores

Figure 1 demonstrates the synoptic map of the 700 hPa level representing the pattern of the establishment of ASTAC systems on the Hormuz Strait. As was observed in Table 1, across seven precipitation systems, the ASTAC central core lies within the Hormuz Strait range. Almost in all seven systems in this pattern, the Arabian high has a southwestern-northeastern stretching. Visual investigation of the anticyclone development zone in this pattern at all levels of 1000 to 700 hPa indicated that half of the anticyclone circulation zone lies on warm waters of the Oman and Arab seas. In this state, the humidity of these seas in the anticyclonic circulation and north-northeastern streams is gradually advected over Ethiopia and Sudan. Then, it transfers to western Arabia and Iran through the southern and southwestern streams of the trough front. This high establishment pattern causes the precipitation region to be transferred to the southwest of Iran and develop along a southwestern-northeastern direction over Iran. The central axis of the special moisture chart of the 850 hPa level of this group indicated that across all these systems, the main origin of humidity is advected from the humidity core deployed on eastern Ethiopia and southeastern Sudan with a southwest-northeast direction along the trough front stream over Iran. In this pattern, the northwest and southeast of Iran have poor precipitation. As can be seen, the axis of troughs of this group of systems is deployed within the longitudes of eastern 32-40° (with a focus on the eastern coast of the Mediterranean Sea and the eastern side of Egypt). In most cases, the southern end of the trough extends up to the south of 20° latitude (Fig. 1C). As can be seen in Figure 1B, in this group, the maximum precipitation core lies over the north of Khuzestan province and the slopes of the middle Zagros mountain ranges. In this group, the average distance between the precipitation core and the high-pressure central core is around 1007 km. The high-precipitation core lies in the northwestern region of the high core.

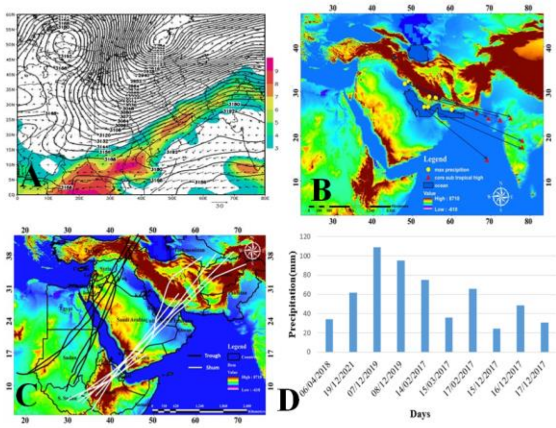

Fig. 1: A: the combined topography map, special moisture, and stream; B: the location of high-pressure and maximum precipitation cores; C: the axis of trough and humidity (at the level of 850 hPa); D: the level of precipitation in the selected samples

The pattern of India and Pakistan cores

Figure 2 represents this synoptic pattern at the level of 700 hPa. In this pattern, the high-pressure central core is deployed in the northwestern coast of India or the southeast of Pakistan. Considering the eastward displacement of the ASTAC central core and the synoptic pattern governing such systems, the eastern Mediterranean trough takes a different form compared to other systems. As can be seen in Figure 2A, the trough is very deep. Furthermore, in all cases, the trough finds northeastern-southwestern stretches. The concentration of troughs axis is on western Iraq and the northwestern of the Arabian peninsula, which, in comparison to Hormuz Strait group systems, has moved eastward by around 5-6° of latitude. The southern end of troughs usually extends down and below the northern 10° latitude, which, in comparison to the previous group, suggests greater depth of troughs and their considerable southward extension. In this pattern, similarly, the humidity origin begins from over Ethiopia and southern Sudan. In this state, the southern zone of the high-pressure cell with eastern streams transfers the humidity of warm seas, the Arabian Sea, and the Gulf of Aden into Ethiopia and Sudan. As indicated in Figure 2C, the main axis of the advected special moisture enters Iran after passing over the south of the Red Sea and the north of the Bab-el-Mandeb Strait and over the south of the Arabian Peninsula and the west of the Hormuz Strait. In this pattern, the precipitations begin from the south of Iran and cover the eastern and southeastern halves of Iran along the southern trough front streams. Conversely, the center, southwest, west, and north of Iran have poor precipitation. This is the most suitable pattern for winter precipitations of south and southeast of Iran, Afghanistan, and Pakistan. As shown in Figure 2B, in this pattern, the precipitation cores are located around the Strait of Hormuz and north of Hormozgan Province and its islands. In this pattern, the precipitation cores occur on the northwestern side of the high-pressure system. The distance of the precipitation core in this pattern from the high core is around 1978 km on average. In comparison to the distance of the cores in the previous group, it increased to around 971 km.

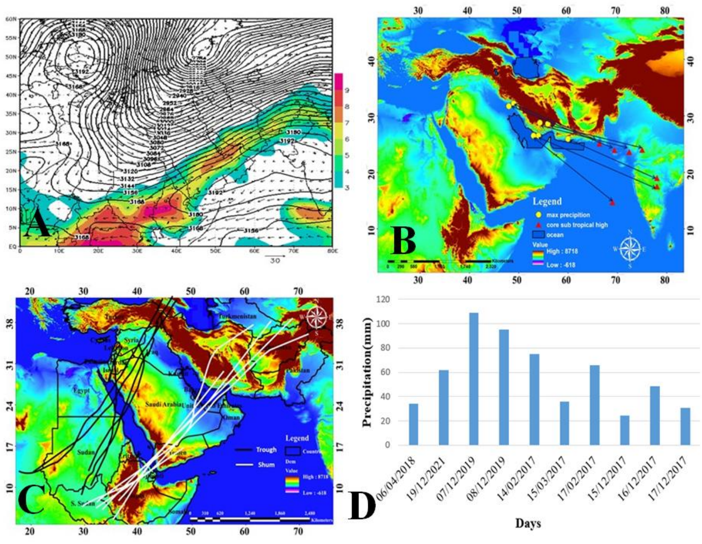

Fig. 2: A: the combined topography map, special moisture, and stream; B: the location of high-pressure and maximum precipitation cores; C: the axis of trough and humidity (at the level of 850 hPa); D: the level of precipitation in the selected samples

The pattern of eastern coast cores of Arabian Peninsula

Figure 3 demonstrates the synoptic pattern of stations where the central high core of Arabia lies over the eastern coast of the Arabian Peninsula. In this state, the high central core has around 3-5° eastward displacement compared to the Strait of Hormuz. However, its mechanism of action is very similar to the synoptic pattern of the Strait of Hormuz. In this state, again the anticyclone circulation pattern across all middle and lower layers of the troposphere is such that the whole or a major part of the anticyclonic circulation zone lies over Arab and Oman warm waters. The stretching pattern of the system's axis is northeastern and southwestern. The axis of troughs has a greater distribution compared to the two previous patterns, where the axis of troughs is distributed from 28° (western Cyprus) up to 42° (western Iraq). The axis of troughs has a lower angle compared to both groups, and the axes have become more meridianal. The southward extension of troughs is less compared to the two previous groups (Figure 3C). For this reason, the intensity and zone of development of the precipitations of this group are more diverse than those of other groups. However, overall, the intensity of its precipitation is lower than that of others, and its precipitation zone is wider. In this pattern, throughout the entire lower troposphere layer, a part of the ASTAC cell lies over Oman and Arab warm waters; therefore, through anticyclonic circulation, it transfers the humidity of these seas into the Sudan low system. Therefore, in this pattern, the humidity origin of streams is from over Ethiopia and southern Sudan. The humidity streams pass over the south of the Red Sea up to the northern 20° within the range of the Bab-el-Mandeb Strait. Then, after passing over central Saudi Arabia, it enters Iran in a zone between the Strait of Hormuz and Kuwait. Thus, the zone of the passage of the humidity axis is wider than that of the two previous groups (Figure 3C). Hence, its precipitation zone is also wider in Iran. In other words, in this pattern, almost all the points in Iran have the chance of receiving precipitation. In this group, except for two cases of the systems, where the high precipitation core is located over the northern regions of the Strait of Hormuz, in other cases, an extreme precipitation core is located over Khuzestan. In this group, the anticyclonic system deployment pattern is such that the precipitation systems pass from western Arabia and enter Iran from the southwest. Nevertheless, considering the pattern of development of the location of the ASTAC cell (northeast or east of the Arabian Peninsula), the Sudan systems have entered from different tracks (Figure3B). The mean difference between the precipitation core and the high-pressure core is 1471 km on average.

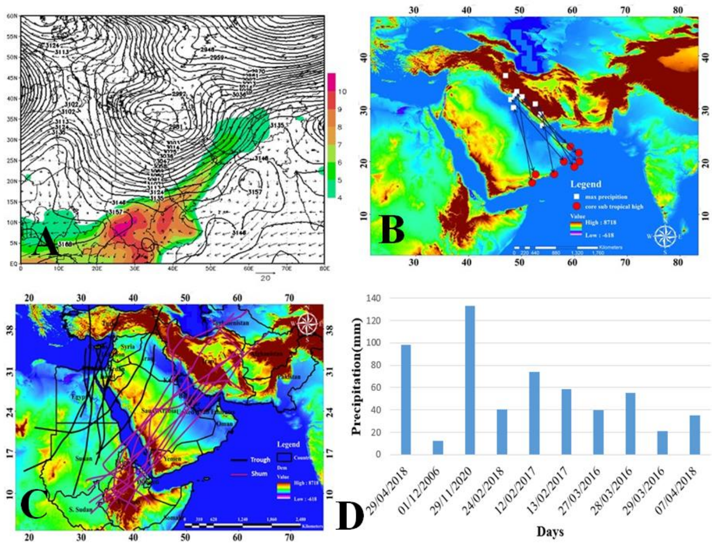

Fig. 3: A: the combined topography map, special moisture, and stream; B: the location of high-pressure and maximum precipitation cores; C: the axis of trough and humidity (at the level of 850 hPa); D: the level of precipitation in the selected samples.

The pattern of the Arabian Peninsula's southern cores

Figure 4 demonstrates this synoptic pattern. In this pattern, the ASTAC central core lies over the southern Arabian Peninsula and generally over Yemen and the Gulf of Aden. The stretching pattern of a high-pressure cell is generally a stretched oval shape with a northeastern-southwestern stretch. Thus, considering the pattern of the development of the ASTAC, the eastern Mediterranean troughs are very diverse in terms of depth of penetration and position of the axis. In the northeastern-southwestern stretch pattern of the high-pressure cell, the Mediterranean trough has a completely eastward displacement and lies over southern Iraq. In this state, they also have a relatively good depth. However, in the western-eastern stretch pattern of the high-pressure cell, the Mediterranean trough is completely westward, and the axis lies over western Cyprus. As can be seen, the troughs do not have a large depth due to the location and development pattern of the ASTAC cell (Figure 4C). It has diminished the depth of troughs below the northern 15° latitude rarely. Considering the location of the high-pressure cell, the humidity enters Ethiopia and Sudan in an anticyclonic circulation through Arab Sea and the Gulf of Aden. Then, it is advected over Iran through southern streams from the central and western Saudi Arabia. For this reason, in this group, the starting point of the advection is over Ethiopia. In this group, the initial track of the humidity advection is mostly similar to that of the India systems group. Nevertheless, they subsequently find various tracks based on the depth and pattern of the trough. The characteristic feature of this group of systems, compared to the three other groups, is the irregularity of the track of the systems entering Iran. These systems can enter Iran within a range between the Strait of Hormuz and Khuzestan. The second important feature of this system is that its precipitation zone is limited to the southern band of the country, and that they do not show any considerable development over Iran. Furthermore, the sum of the system's precipitation is less than that of other systems. The extreme precipitation core in this pattern is mostly located over Khuzestan. The precipitation core occurs in the northwestern side of the core, and the mean distance of the cores in relation to the precipitation core is around 1551 km in this pattern.

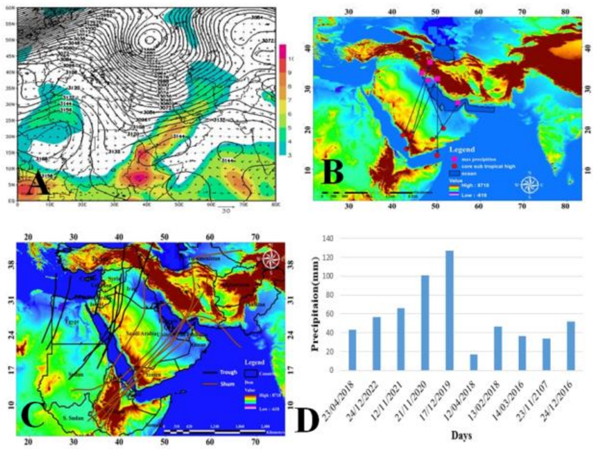

Fig. 4: A: the combined topography map, special moisture, and stream; B: the location of high-pressure and maximum precipitation cores; C: the axis of the trough and humidity (at the level of 850 hPa); D: the level of precipitation in the selected samples

Conclusion

In this study, by analyzing 40 extreme and flood-producing precipitation systems over different regions of southern Iran, the role of the location of the Arabian Subtropical High-Pressure (ASTAC) core in determining the tracks of precipitation systems was investigated. The results showed that the central core of the ASTAC is generally located in four distinct regions around the Arabian Sea and Oman Sea. The spatial position of the ASTAC core in each region determines the movement pathways of precipitation systems and influences moisture advection toward these systems. In all identified circulation patterns, precipitation occurs mainly to the northwest of the high-pressure core. The mean distance between the precipitation core and the high-pressure core was estimated at approximately 1051 km. The moisture sources of all precipitation systems were primarily located over the Arabian Sea and Oman Sea. After accumulating moisture over southern Sudan and Ethiopia, this moisture was transported from the western flank of the ASTAC through southerly flows across the Arabian Peninsula toward Iran. The moisture flux maps clearly demonstrated the dominant role of the Arabian Sea and Oman Sea in supplying moisture for precipitation systems entering from the south. These findings are inconsistent with the results reported by Rafiani et al. (2014); however, they are consistent with the results of Karimi et al. (2019), Lashkari and Mohammadi (2019), Khosravi et al. (2017), Kumar et al. (2008), keikhosravi et al. (2022) and Lindsay and Daberton (1993). This study demonstrated that the location of the ASTAC core plays a key role in determining the pathways of precipitation systems entering Iran and neighboring regions from the south. When the high-pressure core is positioned over the Strait of Hormuz, precipitation systems tend to move toward western Arabia, Kuwait, southern Iraq, and southwestern Iran. In contrast, when the high-pressure core shifts toward northwestern India and southern Pakistan, the Sudan Low pathway extends across the western Gulf of Aden, central Saudi Arabia, and southern Iran. When the ASTAC core is located near the eastern coast of the Arabian Peninsula, the pathway of precipitation systems becomes more variable and extensive, allowing Sudan Low systems to follow different trajectories across the Arabian region and enter Iran between the Strait of Hormuz and Khuzestan. Under this configuration, the spatial extent of precipitation over Iran also increases. In the pattern characterized by the location of the high-pressure core over southern Saudi Arabia, precipitation is generally restricted to Saudi Arabia and the southern half of Iran. The importance of this study lies in improving the understanding of the role of the Arabian Anticyclone (AAC) in controlling the spatial variability of precipitation systems and moisture transport pathways over southern Iran. Identifying the relationship between the AAC core position and the movement tracks of precipitation systems provides valuable insights into the mechanisms governing extreme and flood-producing rainfall events. The results can contribute to improving synoptic forecasting, early warning systems, and risk management strategies for reducing the impacts of heavy precipitation on vulnerable regions and infrastructures.

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